Chapter One

Bridge Construction Overview

This chapter provides an introduction to bridge construction inspection. The following topics are discussed:

- Certified Technician's duties
- basic bridge terms,
- bridge plans, and
- construction controls and layout.

Certified Technician's Duties

The general duties of a Certified Technician are essentially the same as for all other technicians. These duties are defined in Section 105.09 of the Standard Specifications and are summarized here for easy reference.

Certified Technicians employed by the Department are stationed on the job to:

• Keep the Project Engineer or Supervisor (PE/PS) informed of the progress of the work and the manner in which it is being done;

• Report whenever it appears that the materials furnished and/or the work performed fail to fulfill the requirements of the Specifications and the contract; and

• Call to the attention of the contractor any known deviation from, or infringement, upon the plans and specifications with respect to materials and workmanship as they occur.

Technicians should keep informed about the contractor's planned work for each day, including the location of the work, the work to be done, how much will be done, and what equipment will be used. The technician is expected to complete the required daily reports and submit them promptly to the PE/ PS.

Certified Technicians are authorized to inspect all work performed and materials furnished by the contractor. They have the authority to reject defective materials and to suspend any work that is being done improperly subject to the final decision of the PE/PS. Technicians cannot change any requirement of the plans or specifications nor are they allowed to act as foremen or perform other duties for the contractor.

Basic Bridge Terms

An important first step in understanding the principles and processes of bridge construction is learning basic bridge terminology. Although bridges vary widely in material and design, each will have many components in common. In general, these components can be classified either as parts of a bridge's superstructure or as parts of its substructure. The illustration on the following page shows the components of a typical structure.

Superstructure

The superstructure consists of the components that actually span the obstacle the bridge is intended to cross. It includes:

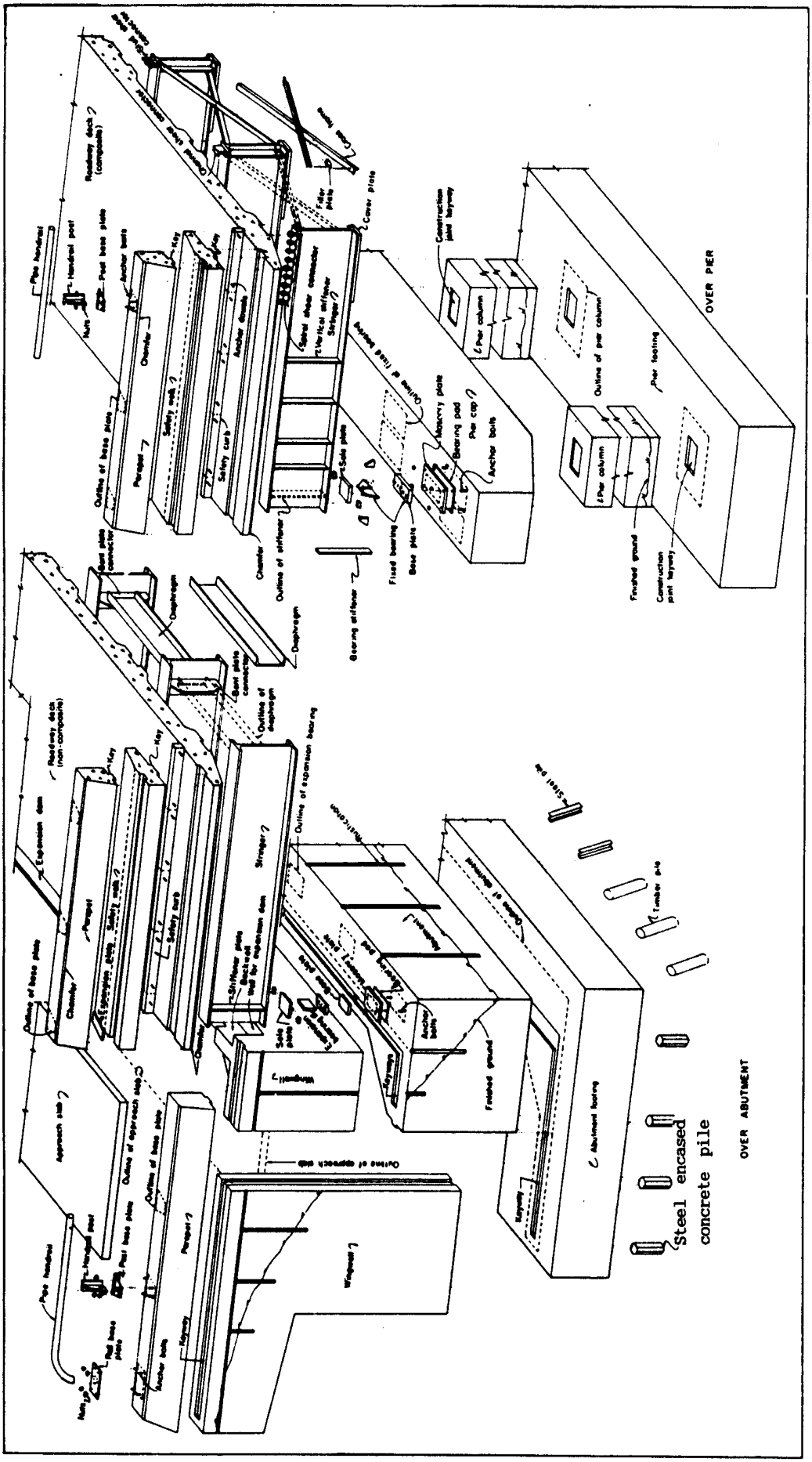
• the bridge deck,

• the structural members, and

• the parapets, handrails, sidewalk, lighting and drainage features.

The deck is the roadway portion of a bridge, including shoulders. Most bridge decks are constructed as reinforced concrete slabs, but timber decks are still seen in rural areas and open-grid steel decks are used in some movable bridge designs.

Bridge decks must conform to the grade of the approach roadway so that there's no bump or dip as a vehicle crosses onto or off of the bridge. The fact is that no matter how big a bridge is or how magnificent its design, all the engineering technology in the world will not make up for a poor riding surface. To most people, the deck is the bridge. It's what they notice as they cross. Or fail to notice. An uneven deck or one that is strewn with potholes is bound to be remembered while a smooth-riding deck will receive little comment or attention.


OVER PIER
OVER ABUTMENT
Steel encased concrete pile

The most common causes of premature deck failure are:

• Insufficient concrete strength stemming from an improper mix design, too much water, segregation, or improper curing;

• Improper concrete placement, such as failure to consolidate the mix as it's placed, or pouring the concrete so slowly that it begins to take its initial set; and

• Insufficient concrete cover due to improper screed settings or incorrect installation of the deck forms and/or reinforcement.

A bridge deck is supported by structural members. The most common types are:

• Steel I-beams and girders;

• Precast, reinforced concrete I-beams;

• Precast, Prestressed reinforced concrete I-beams; and

• Precast, Prestressed concrete box beams.

Secondary members called diaphragms are used as cross-braces between the main structural members and are also part of the superstructure.

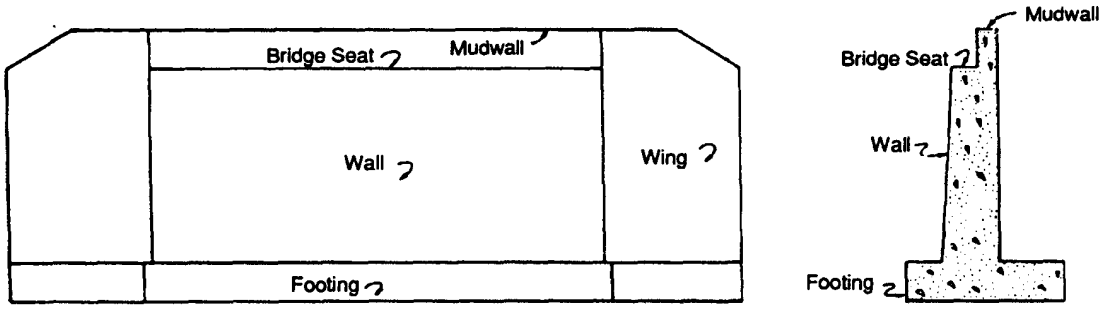
Parapets, handrails, sidewalks, and lighting and drainage features have little to do with the structural strength of a bridge, but they are important aesthetic and safety factors. The materials and workmanship that go into the construction of these features require the same inspection effort as any other phase of the work..

Substructure

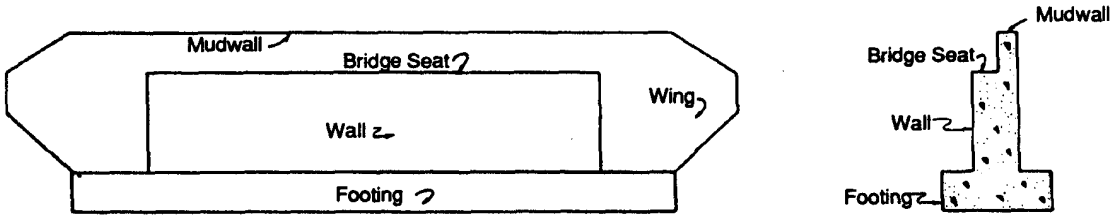
The substructure consists of all parts that support the superstructure. The main components are:

• abutments or end-bents;
• piers or interior bents;
• footings; and
• piling.

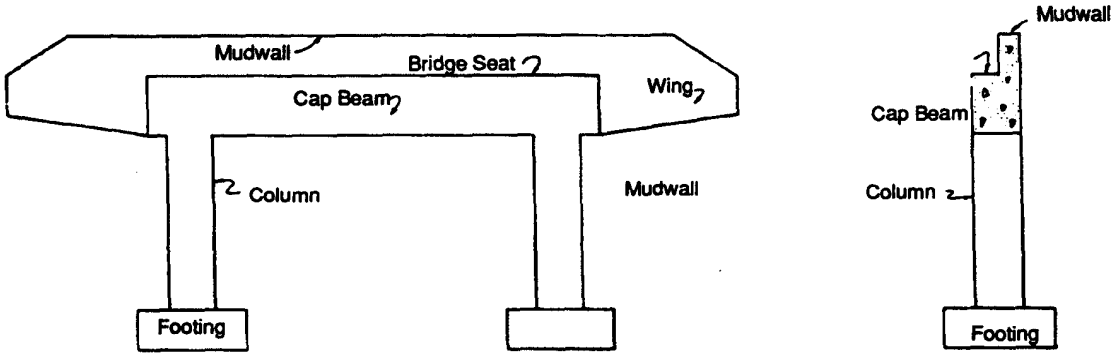
Abutments have two functions. Primarily, they support the extreme ends of the bridge. A secondary function is to confine the approach embankment, allowing it to be built up to grade with the planned bridge deck. Three typical abutment designs are shown on the next page.



Full Height Abutment

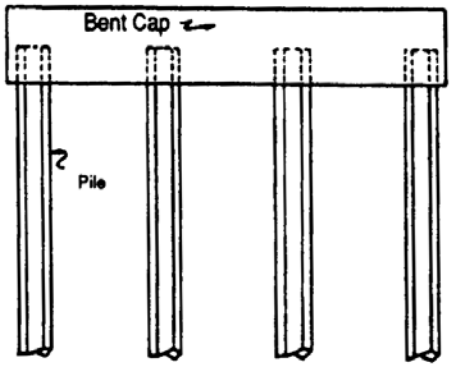


Stub Abutment

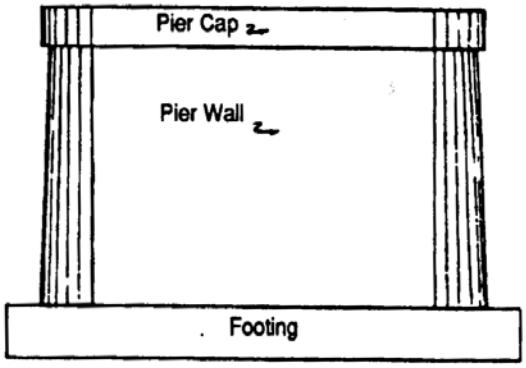


Open Abutment

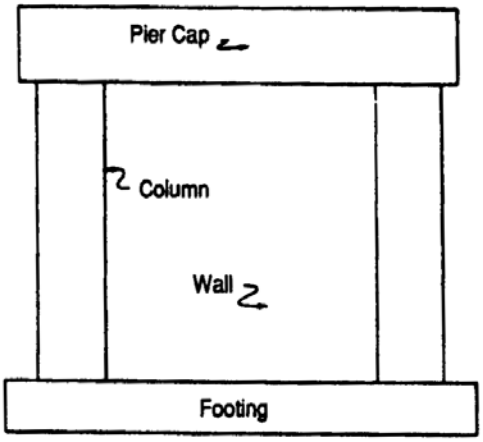
When a bridge is too long to be supported by abutments alone, piers or bents are built to provide intermediate support. Although the terms may be used interchangeably, a "pier" generally is built as a solid wall, while "bents" are usually built with columns.



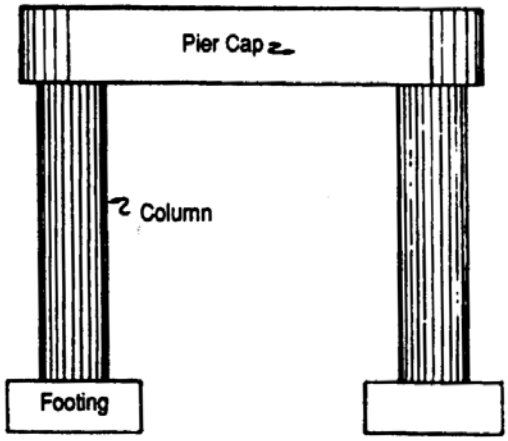
Pile Bent



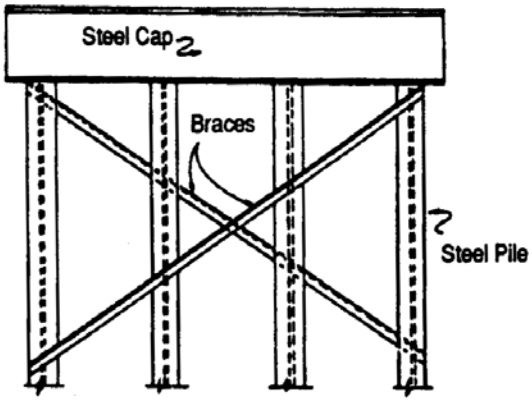
Solid Pier



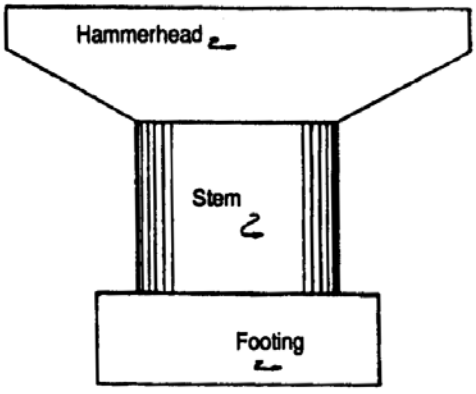
Column Pier with Solid Wall



Column Bent or Open Pier



Steel Bent

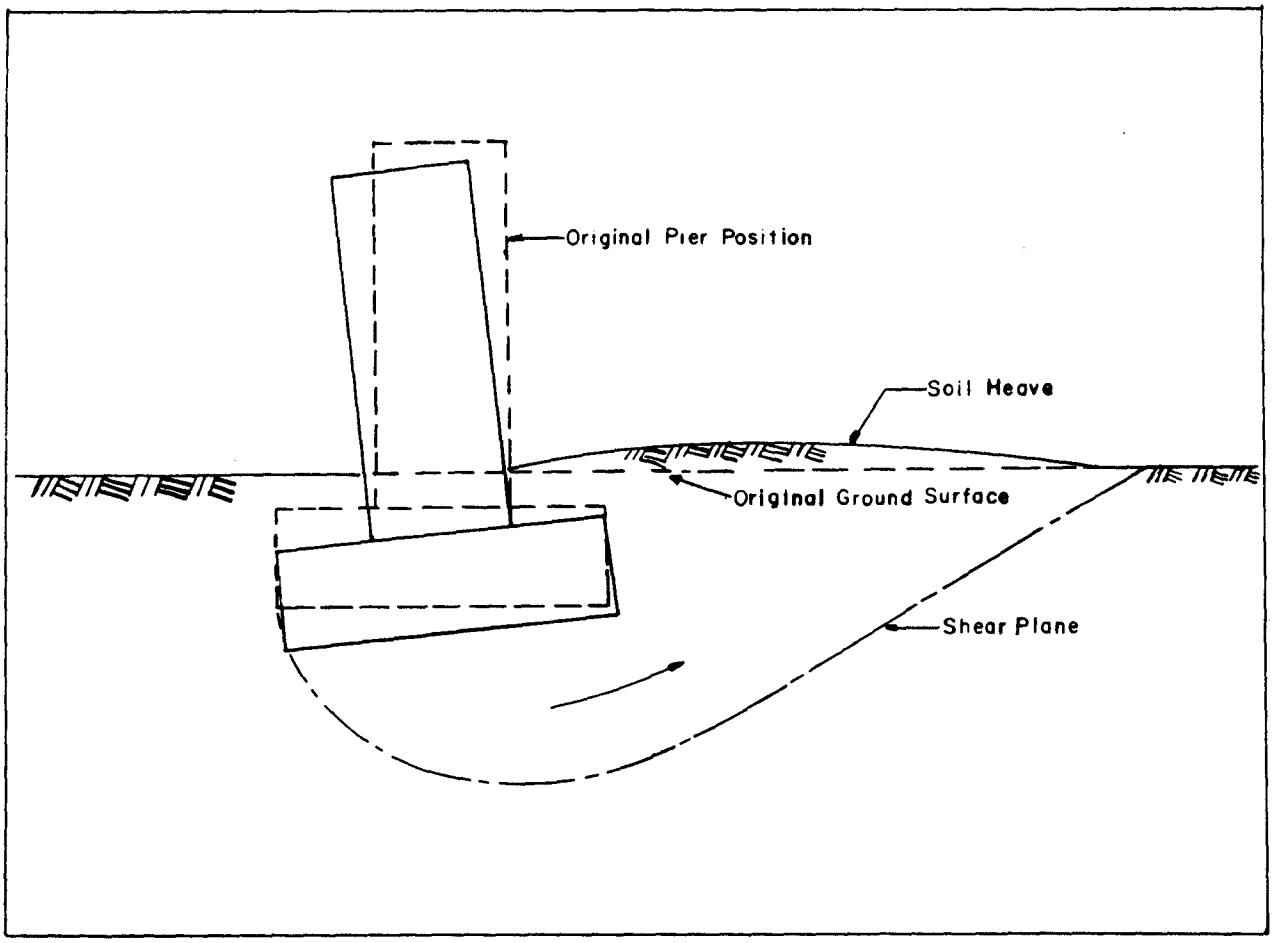


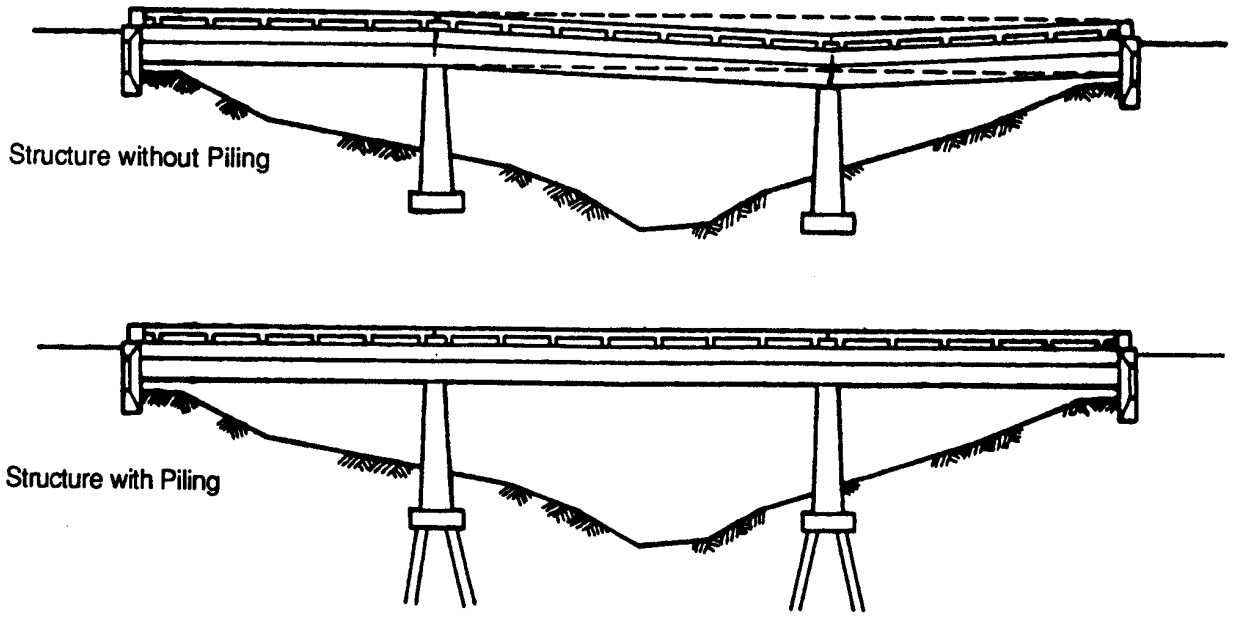
Cantilever Pier or Hammerhead Pier

The top part of abutments, piers, and bents is called the cap. The structural members rest on raised, pedestal-like areas on top of the cap called the bridge seats. The devices that are used to connect the structural members to the bridge seats are called shoes or bearings.

Abutments, bents, and piers are typically built on footings. Footings are large blocks of reinforced concrete that provide a solid base for the substructure and anchor it against lateral movements. Footings also serve to transmit loads borne by the substructure to the underlying foundation material.

When the soils beneath a footing are not capable of supporting the weight of the structure above it, bearing failure occurs. The foundation shifts or sinks under the load, causing structure movement and damage.





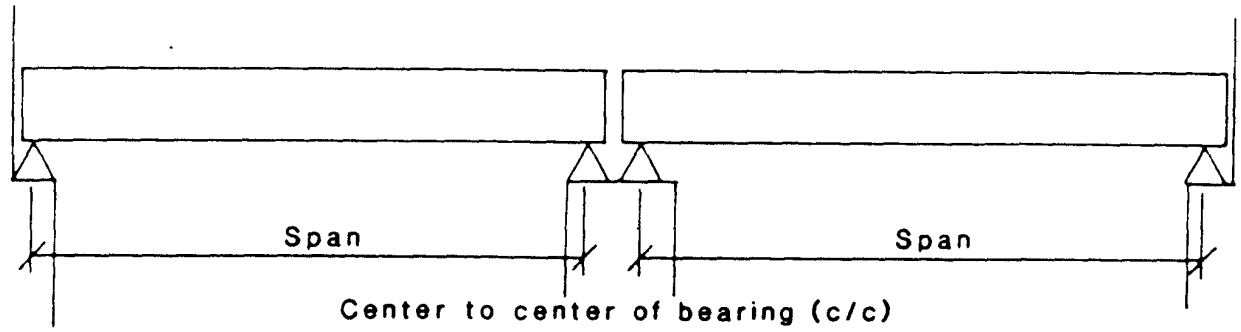
In areas where bearing failure is likely, footings are built on foundation piling. Piling, or piles, are load-bearing members that are driven deep into the ground at footing locations to stabilize the footing foundation. Piling transmits loads from the substructure units down to underlying layers of soil or rock.

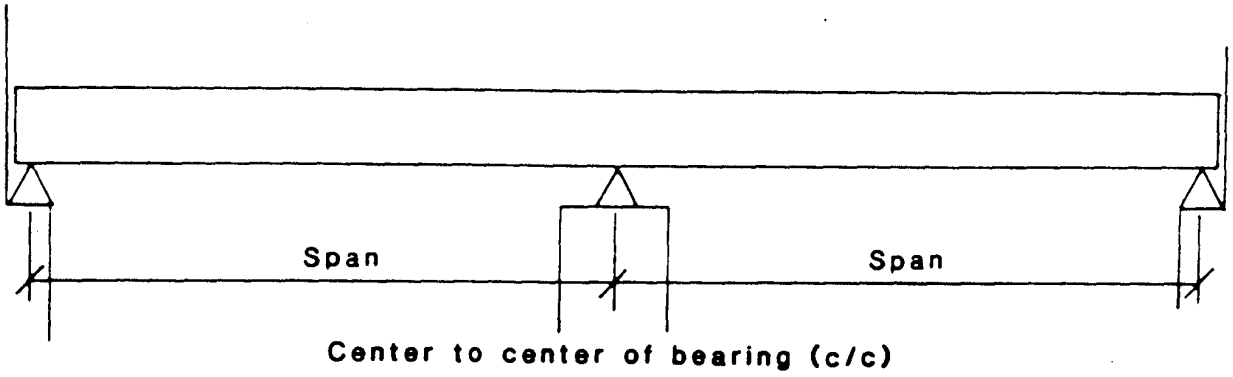
Spans and Span Length

To most people the terms " bridge" and "span" are interchangeable; they mean the same thing. To avoid possible confusion and misunderstanding, technicians and construction personnel draw a distinction between the two.

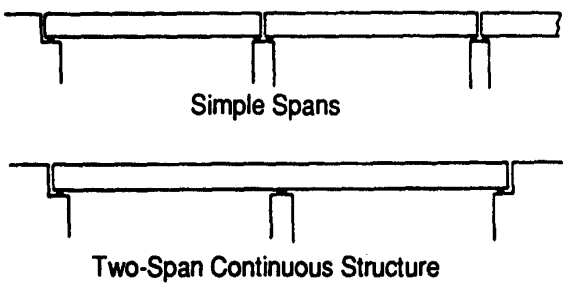
A bridge is made up of spans, one or many. A span is a segment of a bridge that crosses from one substructure unit to the next: from abutment to abutment, from abutment to pier, from pier to pier, or from pier to abutment.

Span length refers to either the length of any individual span within the structure or to the total bridge length. In most cases, span lengths are considered as the distance between centerlines of bearing from one substructure unit to the next, as shown on the next page.





Simple and Continuous Spans



In addition to its basic design (girder, arched, trussed, suspension, etc.), a bridge can be further classified as a simple span, a continuous span, or a combination simple, continuous span. The classification is based on the arrangement of the bridge's structural members.

A span whose structural members cross from one substructure unit to the next and stop is a simple span. It has fixed bearings on one end and expansion bearings on the other. Any bridge that is supported by abutments alone is a simple span. An individual span within a bridge that goes from abutment to pier or pier to pier is also a simple span. Many bridges are in fact constructed as a series of simple spans.

A continuous span is a bridge or bridge segment whose structural members cross over one or more substructure units without a break. The structural members may have to be spliced to obtain the necessary length, but they're still considered one-piece members. Continuous spans will typically be anchored to the substructure by a number of expansion bearings and a single fixed bearing. It's common for a bridge to contain both simple and continuous spans.

Bridge Plans

Bridge plans are generally attached as supplements to roadway construction plans. The basic types of sheets in a set of bridge plans are described below.

Title and Index Sheet

This sheet, usually the first, identifies the bridge by project number and location. It also contains an index of all other sheets in the plans, including the standard drawings that will be used.

Boring Data Sheets

These sheets show the results of soil borings made at the bridge site prior to construction. The Certified Technician uses them to find out about the types of soils that will be encountered during structure excavation and the approximate depths at which they occur.

Layout Sheet

The layout sheet consists primarily of two drawings: a topographical situation plan of the bridge site and a profile view of the proposed bridge grade.

The situation plan identifies landowners and natural and manmade features in the project area. It also delineates right of way limits, limits of construction, and the locations of benchmarks used for grade control. The layout sheet also may include a list of utilities in the project area that might be affected by the construction project.

General Plan

The General Plan sheet includes two views of the bridge: a plan view -- the bridge seen from above -- and an elevation view -- the bridge seen from the side.

The plan view identifies:

• The exact location of the bridge in terms of the project's station numbers and the obstacle the bridge is intended to cross;

• The degree of skew, if any;

• All important centerlines -- structure, roadway, bearing;

• The overall length of the bridge and the lengths of all intermediate spans; and

• All significant widths -- "out to outs," roadways, shoulders, sidewalks, parapets.

The elevation view identifies:

• Original and projected ground lines;

• Elevations of railroads, low water lines, highways, etc., to be crossed and any minimum vertical clearance requirements;

• Minimum tip elevation for piling, if used, and the planned bottom-of-footing elevations; and

• The locations of fixed and expansion bearings.

The General Notes section of the plans may also be included on the General Plan sheet or it might be found on a separate sheet. Much of the information found in the General Notes is "boilerplate" information that will be essentially the same on all similar bridge projects, but there's usually additional information that is project-specific.

Detail Plan Sheets

As the name implies, these sheets provide details not possible in the general plan and elevation views. Typically, detail sheets are provided for each unit of the substructure, a framing plan (superstructure detail), and floor details that describe how the bridge deck is to be built.

In many cases, identical or very similar bridge features will be described on the same detail sheet. For example, the plans for a bridge that has two nearly identical piers will include one detail sheet to be used for both piers. Any significant differences between the two piers will be noted on the plans.

Detail sheets will also include a Bill of Materials section. The Bill of Materials lists the types and quantities of the materials that are needed to construct that particular part of the bridge according to the plans. The materials listed are primarily concrete and reinforcing steel, but miscellaneous items such as bearing pads, surface seal, expansion joints, and roadway drains will be noted as well.

Bridge Summary and Estimate of Quantities Sheets

The bridge summary sheet is a tabulation of quantities of material used in each part of a bridge. The Estimate of Quantities sheets list the totals of materials used in the entire bridge by pay item.

Standard Drawings

Just about every bridge construction project will have features in common with bridges of similar design, size or location. Such items include railing details, pile splicing methods, details on bearing assemblies, and many more. Producing new drawings for these features every time they're to be included on a project would be time-consuming and repetitious. Instead, plans for such items are included in the Department's series of Standard Drawings for Bridges. Normally, the Department assembles all of the Standard Drawings that will be used on a project and distributes them to the contractor and other project personnel.

Contractor's Plans or Drawings

In addition to the plans and drawings furnished by the Department, some bridge plans are supplied by the contractor. These plans show the contractor's proposed methods of meeting the requirements of the Department's plans, the Special Provisions, and the Standard and Supplemental Specifications. In all cases, contractors' plans must be submitted to and approved by the Department.

The following items require approval:

- Falsework and cofferdam plans;
- Shop plans for the fabrication and erection of structural members;
- Deck pour plans and or sequence;
- Traffic control plan alternatives; and
- Erosion control plan.

Any work performed prior to the receipt of the approved plans is done at the contractor's risk. The contractor's drawings are approved for design features only. Approval does not relieve the contractor from responsibility for errors or for the adequacy and safety of the work.

Construction Controls and Layout

Horizontal Controls

To maintain the horizontal alignment of a bridge -- that is, to make sure it lines up correctly with the approach roadways -- the initial survey and layout establishes one or more centerlines to guide the construction. The important centerlines to check include:

• The centerline of construction (sometimes referred to as baseline of construction or survey line);

• The centerline of structure;

• The centerline of roadway; and

• The centerline of bearing (may also be called centerline of pier).

Depending on the project, the centerlines of construction, structure, and roadway can be the same line or three different lines. For example, a two-lane bridge with no shoulders or with shoulders of equal widths would probably have one line for all three references. In most cases, though, one or more centerlines will be different from the others.

Centerlines of bearing are transverse lines that bisect the bridge seats or bearing areas on abutments and piers and intersect the longitudinal centerlines. Generally, if the centerlines of bearing intersect the longitudinal centerlines at an oblique angle (an angle other than a right angle), the bridge is said to be skewed or "built on a skew." If the centerlines of bearing intersect. the longitudinal centerlines at right angles, there is no skew. Degrees of skew, if any, are noted on the General Plan sheet and elsewhere on the plans.

Vertical Controls

To maintain the proper grade of a bridge and the elevation of its various components, all construction must be referenced to benchmarks: points of known elevation. Benchmarks guide everything from structure excavation and pile driving to pouring the bridge deck.

Benchmarks for bridges are established during the bridge layout and their locations are usually noted on the layout sheet. At least one benchmark on each side of the bridge should be checked for accuracy before construction begins. If the present benchmark is on a structure that will be removed, a temporary benchmark should be established and protected at a site convenient to the new bridge. As soon as a footing or other permanent part of the new structure is poured, the temporary benchmark should be transferred to the new structure.

Bridge Construction Layout

Bridge layout and staking is normally done by the Contractor, or Subcontractor, as Construction Engineering. Layout involves establishing construction control points that will be used to maintain the horizontal and vertical alignment of the work that follows. After performing the layout, the Surveyor furnishes the contractor with the information needed to complete the layout and to perform the work. Technicians who have little or no survey work experience should participate in the layout operation to acquaint themselves with the locations of important construction control points and the methods used to establish those points. The following is a brief description of the procedure.

The first step in bridge layout is to locate previously established control points on each end of the bridge site. The control points were established during the preliminary survey to represent the baseline of construction or the survey line. This line is typically designated as Line "A" on the plans.

Control points for the centerline of structure and/or roadway should also be located if they're different from the survey line. All points should be checked for alignment and referenced with offset stakes. The station of one of the control points should be determined for use in locating the abutments and piers.

The next step is to locate each unit of the substructure at points along the survey line. Reference stakes for these points are set to the left and right of the centerline by turning the skew angle. To insure accuracy the survey crew should double and triple the skew angle. The accuracy of the skew angle can be checked by measuring the distance between reference points on the left and right sides. If the distances between the points are equal on both sides, the skew angle is correct.

It's important that enough reference points are set to insure easy replacement of the centerline control. The reference points should be protected and identified by guard stakes.

Once the reference points are set, the crew double-checks the elevations of bench marks. Again, temporary benchmarks must be established when a bench mark on an existing structure is to be replaced. If the bridge deck is to match an existing roadway, the edges and centerline of the roadway must be profiled and checked against the elevation of the new structure.

The last step in bridge layout is staking the footings and taking cross-sections of the footing areas. The cross-sections will be used to determine how much material the contractor will have to remove during structure excavation.